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| *Title:* | An Overview of the Source Physics Experiments (SPE) at the Nevada National Security Site (NNSS) |
| *Author(s):* | Catherine Snelson (NSTech)<br>Wendee Brunish (EES-17)<br>Chris Bradley (EES-17)<br>Howard Patton (EES-17)<br>et. al. |
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DOE/NV/25946--1281

# AN OVERVIEW OF THE SOURCE PHYSICS EXPERIMENTS (SPE) AT THE NEVADA NATIONAL SECURITY SITE (NNSS)

Catherine M. Snelson, Dennis L. Barker, Robert L. White, Ryan F. Emmitt, Margaret J. Townsend, Thomas E. Graves, Steven A. Becker, Matthew G. Teel, Ping Lee, National Security Technologies, LLC, North Las Vegas, NV; Tarabay Antoun, Arthur Rodgers, William R. Walter, Rob Mellors, Lawrence Livermore National Laboratory, Livermore, CA; Wendee Brunish, Christopher Bradley, Howard Patton, Ward Hawkins, Los Alamos National Laboratory, Las Alamos, NM; Bobby Corbell, Robert Abbott, Sandia National Laboratories, Albuquerque, NM

Modeling of explosion phenomenology has been primarily empirically based when looking at the seismic, infrasound, and acoustic signals. In order to detect low-yield nuclear explosions under the Comprehensive Nuclear Test Ban Treaty (CTBT), we must be able to understand and model the explosive source in settings beyond where we have empirical data. The Source Physics Experiments (SPE) at the Nevada National Security Site are the first step in this endeavor to link the empirically based with the physics-based modeling to develop this predictive capability. The current series of tests is being conducted in a granite body called the Climax Stock. This location was chosen for several reasons, including the site's expected "simple geology"—the granite is a fairly homogeneous body. In addition, data are available from underground nuclear tests that were conducted in the same rock body, and the nature of the geology has been well-documented. Among the project goals for the SPE is to provide fully coupled seismic energy to the seismic and acoustic seismic arrays so that the transition between the near and far-field data can be modeled and our scientists can begin to understand how anisotropy controls seismic energy transmission and partitioning.

The first shot for the SPE was conducted in May 2011 as a calibration shot (SPE1) and was composed of 220 lb (100 kg) of chemical explosives set at a depth of 180 ft (55 m). An array of sensors and diagnostics recorded the shot data, including accelerometers, geophones, rotational sensors, short-period and broadband seismic sensors, Continuous Reflectometry for Radius vs. Time Experiment (CORRTEX), Time of Arrival (TOA), Velocity of Detonation (VOD) as well as infrasound sensors. The three-component accelerometer packages were set at depths of 180 ft (55 m), 150 ft (46 m), and 50 ft (15 m) in two rings around ground zero (GZ); the inner ring was at 10 m and the outer ring was 20 m from GZ. Six sets of surface accelerometers (100 and 500 g) were

placed along in an azimuth of SW from GZ every 10 m. Seven infrasound sensors were placed in an array around the GZ, extending from tens of meters to kilometers. Over 100 seismic stations were positioned, most of which were in five radial lines from GZ out to 2 km. Over 400 data channels were recorded for SPE1, and data recovery was about 95% with high signal to noise ratio.

Future tests will be conducted in the same shot hole as SPE1. The SPE2 experiment will consist of 2200 lb (1000 kg) of chemical explosives shot at 150 ft (46 m) depth utilizing the above-described instrumentation. Subsequent SPE shots will be the same size, within the same shot hole, and within the damage zone. The ultimate goal of the SPE Project is to develop predictive capability for using seismic energy as a tool for CTBT issues.

This work was done by National Security Technologies, LLC, under Contract No. DE-AC52-06NA25946 with the U.S. Department of Energy.

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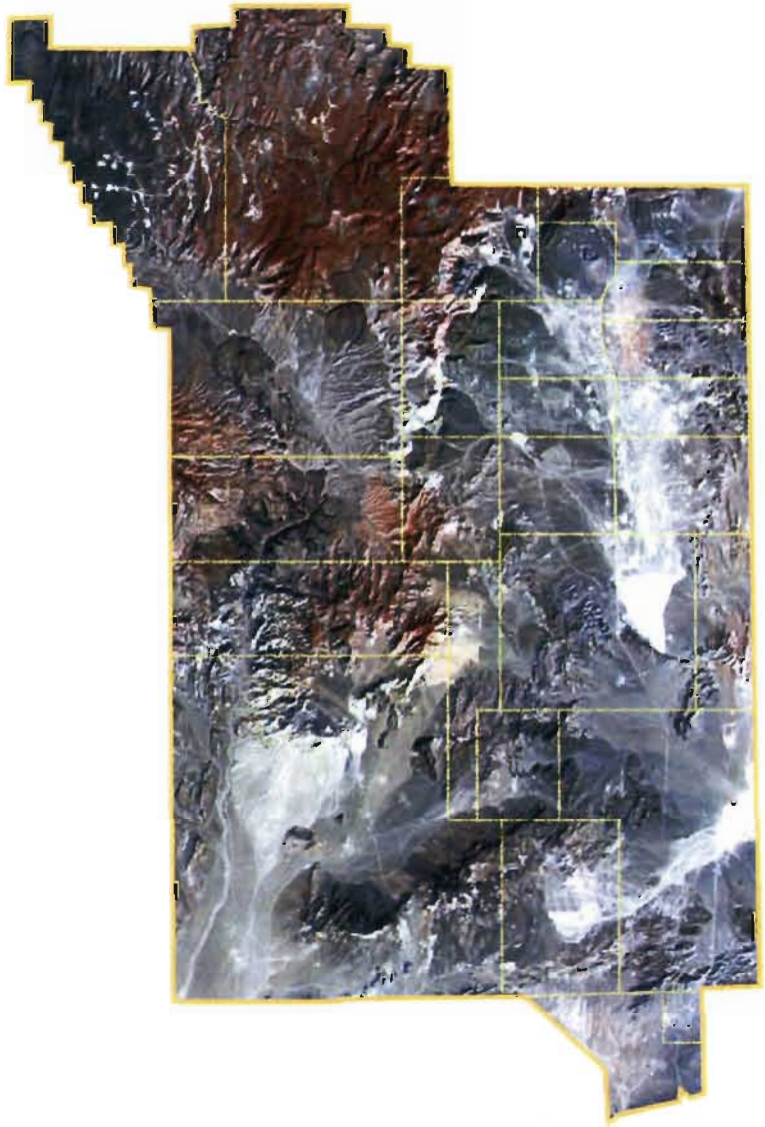
[1]National Security Technologies, LLC, [2]Lawrence Livermore National Laboratory, [3]Los Alamos National Laboratory, [4]Sandia National Laboratory

# Outline

- Objectives
- Geologic Background
- Experiment Layout
- Data
  - Initial Look
- Path Forward



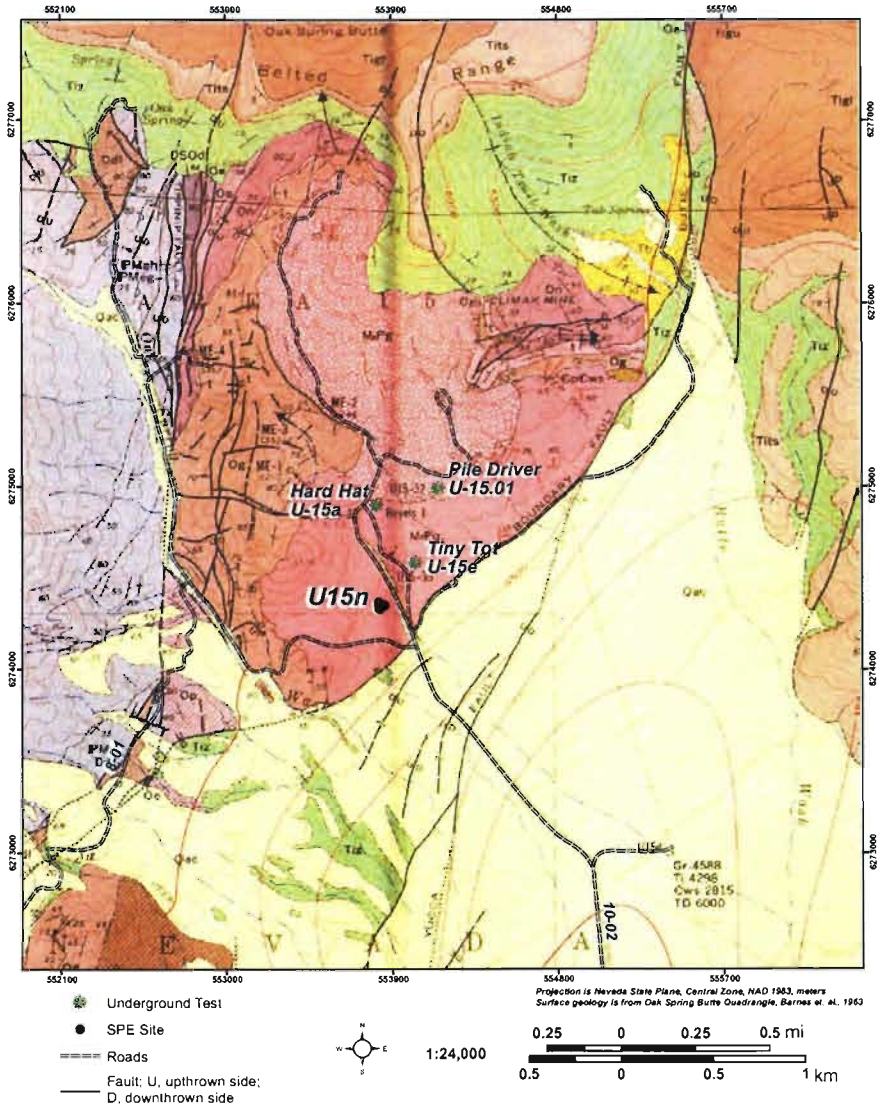
# Source Physics Experiment Series

- **Importance for Comprehensive Nuclear Test-Ban Treaty (CTBT) verification**
  - Understanding the effect of near source characteristics (rock type, geometry, depth, coupling) on seismic wave generation is critical to interpreting IMS and other seismic station signals
  - Enhanced modeling of faults and fractures in hard rock will lead to improved understanding of explosive and seismic signatures for foreign sites of interest for the CTBT

- **Science objectives**
  - Develop new geologic material models that use a physics-based approach to model damage in hard, fractured rock
  - Develop 3-D modeling tools to address the effect of faults and fractures on explosive energy coupling and shear wave generation
  - Evaluate how source asymmetry and surface and subsurface scattering affect shear wave generation and evaluate implications for CTBT monitoring efforts

# Geologic Background

- Climax Stock – U15n
  - Homogeneous granite body
  - Highly fractured/faulted
  - Perched aquifer
- Previous Nuclear Tests
  - Pile Driver & Hard Hat
    - Indicators of anisotropy
- Geophysical Characterization
  - High-resolution seismic reflection/refraction surveys
  - Well logging

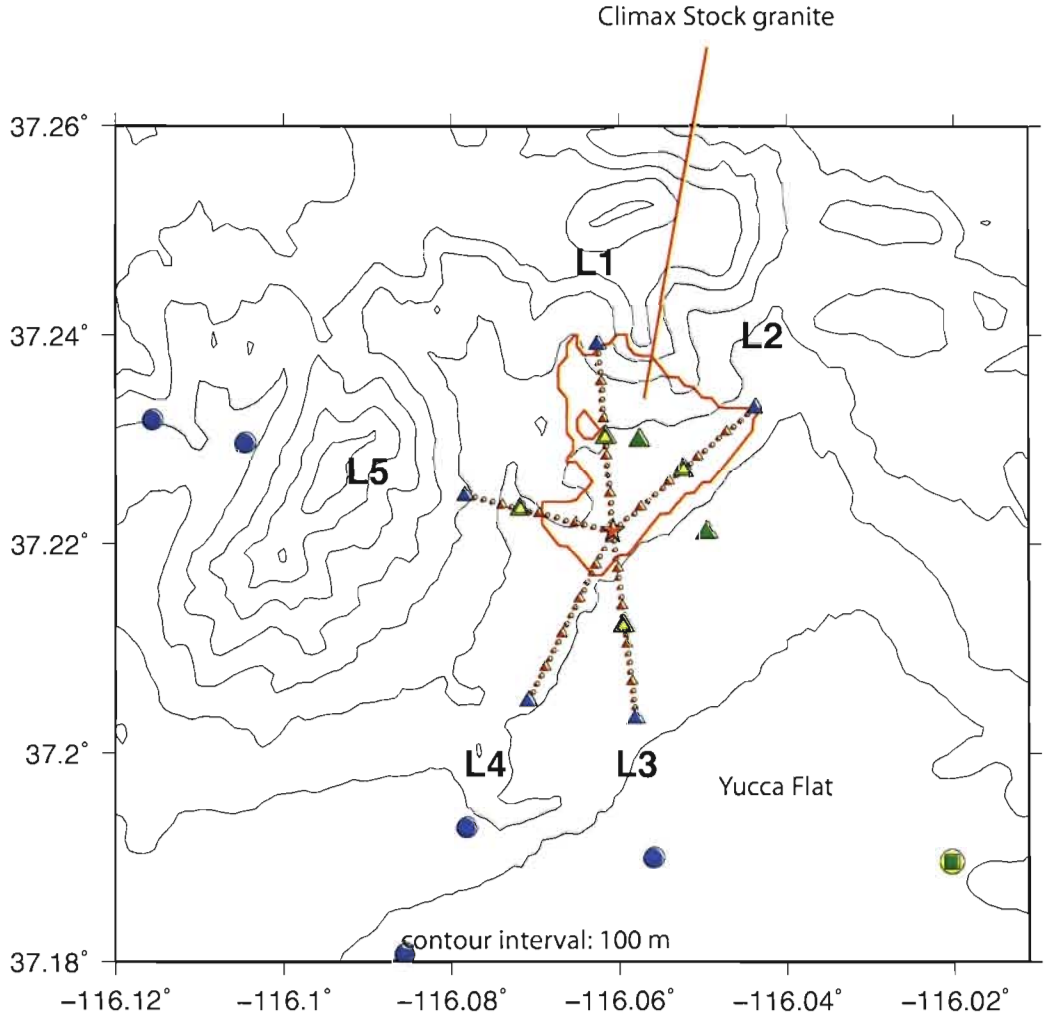


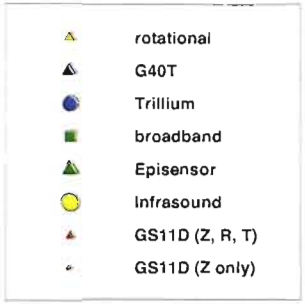
# Source Physics Experiment Layout

- Channels Recorded - **595**
  - Primary 465
  - Secondary 130

- On the canister
- Near-field
- Far-Field

- Imagery



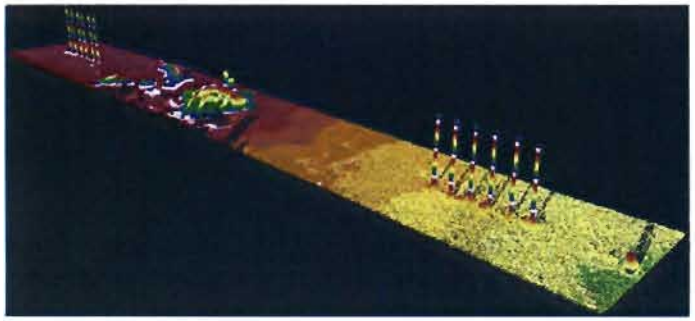



# Explosives

- SPE-1
  - Canister centroid at 180 ft
  - Explosives
    - SHANFO – 219.92 lb (99.8 kg) – TNT equivalent 220 lb (100 kg)
    - Boosters/Dets
- SPE-2
  - Canister centroid at 150 ft
  - Explosives
    - SHANFO – 2571.96 lb (1169.1 kg) – TNT equivalent 2200 lb (1000 kg)
    - Boosters/Dets

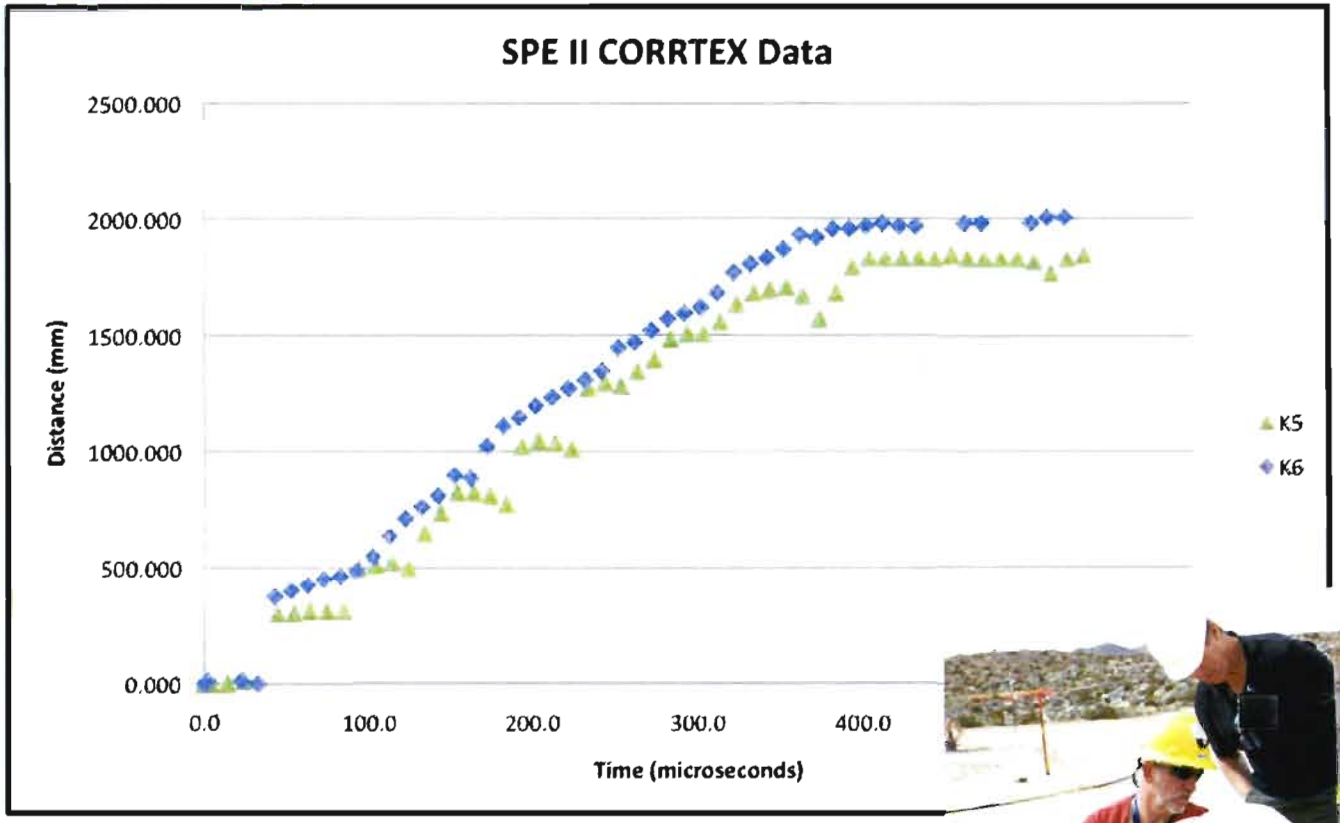
# Imagery

- OSI - Change Detection R&D



# HD Camera on Hill

# CORRTEX



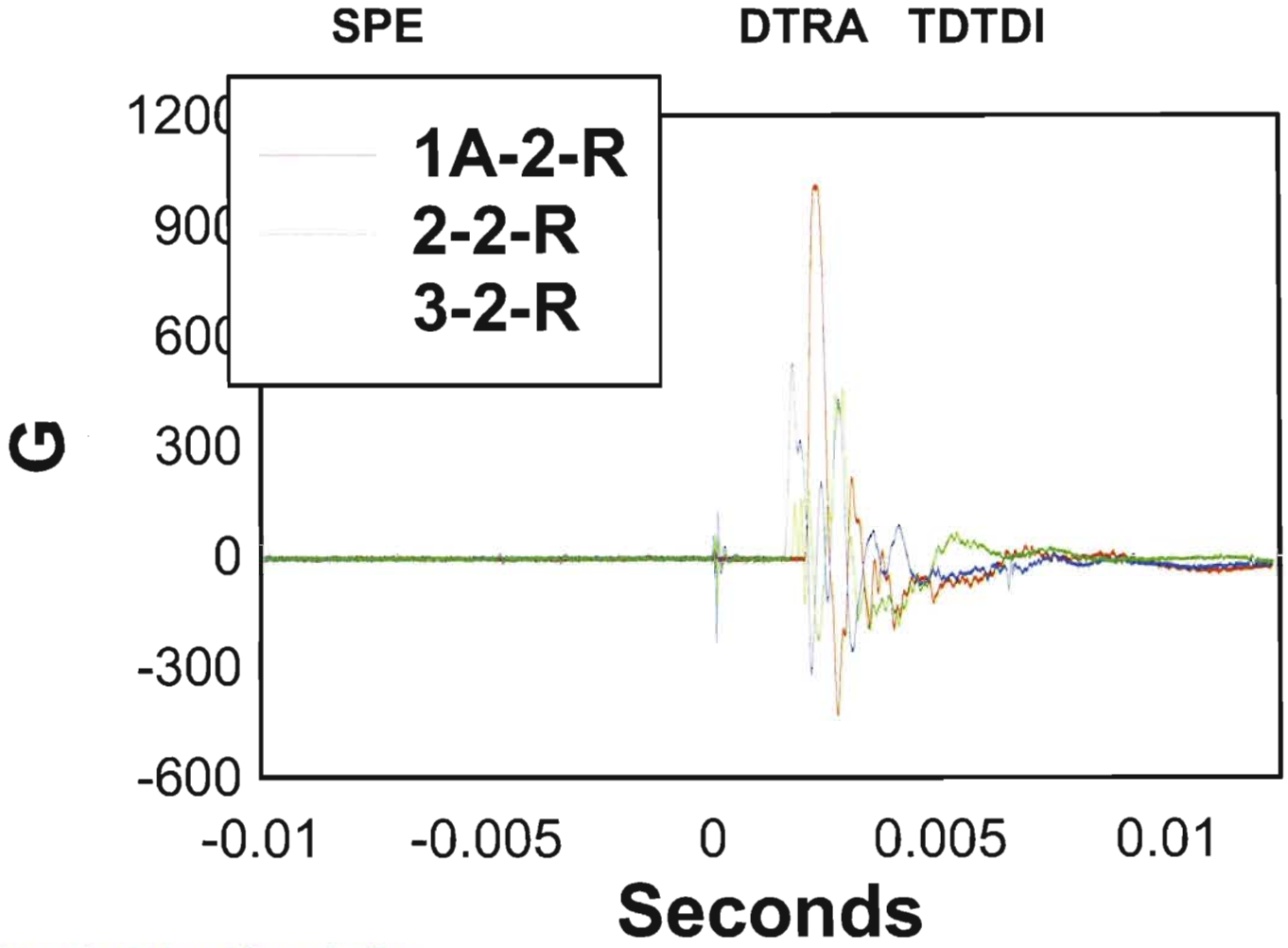

K5

| Speed (mm/us) | +/- |
|---|---|
| 5.185 | 0.153 |

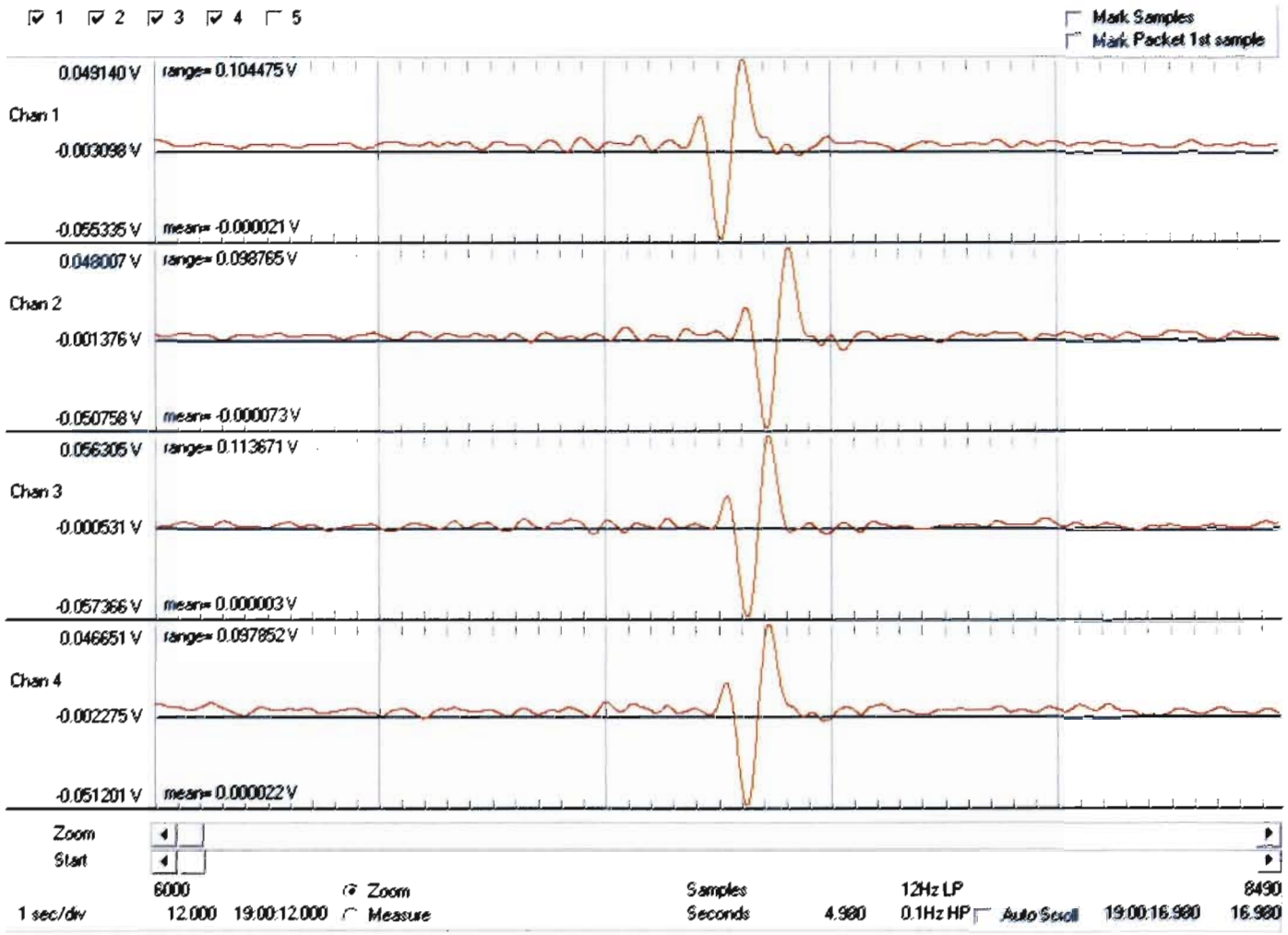
K6

| Speed (mm/us) | +/- |
|---|---|
| 5.204 | 0.095 |

# 10m Radial at 150 ft

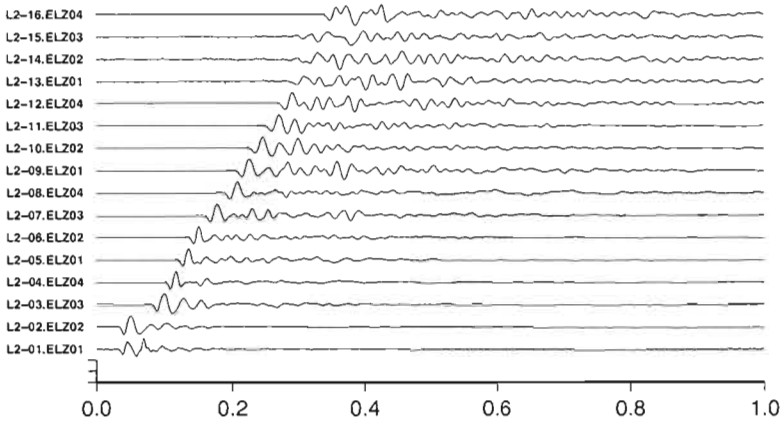


# SPE-2 Infrasound 4.9 km South

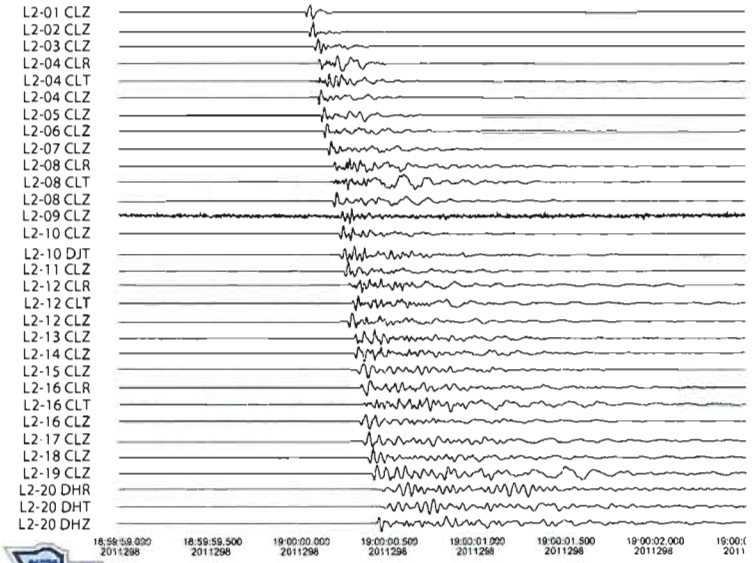


# SPE Seismic Data

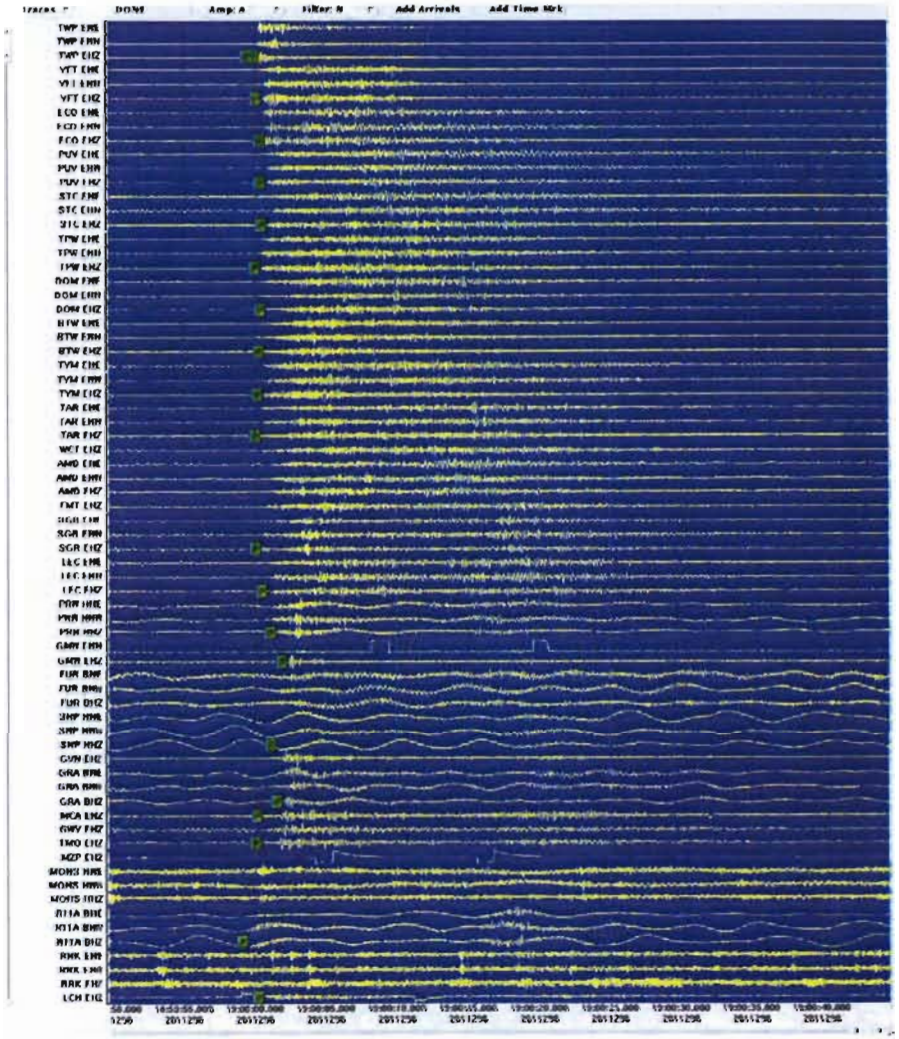
## SPE-1 Line 2




## SPE-2 Line 2




## SPE-2 UNR Network



# Planned Source Physics Experiments FY10 - FY13

| Yield, tons | DOB m | SDOB $m/kt^{1/3}$ | Medium | Comments |
|---|---|---|---|---|
| SPE-1 – 0.1 | 60 | 60 | Granite | Simple geology |
| SPE-2 - 1.0 | 45 | 450 | Granite | Same hole as #1 |
| SPE-3 - 1.0 | 45 | 450 | Granite | In damage zone of shot #2 |
| SPE-4 - 1.0? | 30 | 300 | Granite | Same hole as #1-3 |
| SPE-5 – 1.0? | 15 | 150 | Granite | New hole, Over-buried |
| 1.0? | 20? | 200 | Limestone (U16b) | Complex geology |
| 5.0? | 20? | 117 | Limestone (U16b) | Nominal DOB? |
| 100? | >55? | TBD | TBD | Rock Valley; see Walter LCP |

# Summary

- Data aggregation and reduction in process
- Drilling Core hole into damaged zone
- Adding additional instrumentation holes
- SPE-3 – Spring time 2012
  - 150' (45 m) centroid shot/2200 lb (1000 kg) TNT equivalent
- S43A - Explosion Geophysics II Posters – Thursday, December 8th
  - 1:40 to 6 pm

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